CLAIMS

<u>What is Claimed is</u>:

1. A method of estimating a communication channel impulse response $h(t)$, comprising the steps of:

generating $co_m(t) = co(t + mNT_c)$ for $m = 0,1,\Lambda ,M$ by correlating a received signal $r(t)$ with a spreading sequence S_i of length N, wherein the received signal $r(t)$ comprises a chip sequence c_j applied to a communication channel characterizable by an impulse response $h(t)$, and wherein the chip sequence c_j is generated from a data sequence d_i spread by the spreading sequence S_i and wherein T_c is the chip period of the chip sequence c_j;

generating an estimated communication channel impulse response $\hat{h}_M(t)$ as a combination of $co_m(t)$ and d_m for $m = 0,1,\Lambda ,M$; and

filtering the first estimated communication channel impulse response $\hat{h}_M(t)$ to generate the estimated communication channel impulse response $h(t)$ with a filter f selected at least in part according to the spreading sequence S_i.

2. The method of claim 1, wherein the filter f is further selected at least in part according to an autocorrelation $A(n)$ of the spreading sequence S_i.

3. The method of claim 2, wherein the filter f is further selected at least in part according to the duration of the impulse response of the communication channel $h(t)$.

4. The method of claim 2, wherein the filter f is further selected at least in part according to a zero-forcing criteria $\sum_{i=-L}^{L}(A(n-i) \bullet f(i)) = A_f(n), -L \leq n \leq L$, wherein:

$f(i)$ is the impulse response of the filter f such that $A_f(n)$ is a convolution of $A(n)$ and $f(i)$;

$A_f(n) = 1$ for $n = 0$ and $A_f(n) = 0$ for $0 < |n| \leq L$; and

$A(n) = A(-n) = \sum_{i=o}^{N-1-n} S_i \bullet S_{i+n}, 0 \leq n \leq N$, and N is a length of the chip sequence S_i.

5. The method of claim 4, wherein:

the parameter L is chosen such that a time duration of the impulse response of the communication channel $h(t)$ is less than LT_c.

6. The method of claim 4, wherein:

the parameter L is chosen such that a time duration of the impulse response of the communication channel $h(t)$ is approximately equal to LT_c.

7. The method of claim 1, wherein N is less than 20.

8. The method of claim 1, wherein $M = 0$.

9. The method of claim 1, wherein the data sequence d_i includes a constrained portion Cd_i associated with at least two codes w_0, w_1, wherein a correlation $A_{code}(k)$ of the constrained portion Cd_i with one of the codes w_0, w_1 is characterized by a maximum value at $k = 0$ less than maximum values at $k \neq 0$.

10. The method of claim 9, wherein the step of generating an estimated communication channel impulse response $\hat{h}_M(t)$ as a combination of $co_m(t)$ and d_m for $m = 0,1,\Lambda\ ,M$ comprises the step of computing $\hat{h}_M(t)$ as $\frac{1}{M}\sum_{m=0}^{M-1} d_m \bullet co(t + mNT_c)$.

11. The method of claim 10, wherein $M=2$.

12. The method of claim 9, wherein the data sequence d_i includes a preamble having a pseudorandom code including the constrained portion of the data sequence d_i.

13. The method of claim 9, wherein $A_{code}(k) = 1$ at $k = 0$ and $A_{code}(k) = 0$ for substantially all $k \neq 0$.

14. The method of claim 9, wherein $A_{code}(k) = 0$ for $0 < |k| \leq J$, wherein J is selected to minimize the correlation of the constrained portion Cd_i with the one of the codes w_0, w_1 for substantially all $k \neq 0$.

15. The method of claim 14, wherein $2J$ is a length of the constrained portion Cd_i.

16. The method of claim 1, wherein $A_{code}(k) = 1$ at $k = 0$ and $A_{code}(k) = 0$ for substantially all $k \neq 0$.

17. The method of claim 1, wherein each of the two codes w_0, w_1 comprises two symbols.

18. The method of claim 1, wherein the each of the two codes w_0, w_1 comprises no more than two symbols.

19. The method of claim 1, wherein the codes w_0, w_1 comprise Walsh codes.

20. An apparatus for estimating a communication channel impulse response $h(t)$, comprising:

means for generating $co_m(t) = co(t + mNT_c)$ for $m = 0,1,\Lambda\ ,M$ by correlating a received signal $r(t)$ with a spreading sequence S_i of length N, wherein the received signal $r(t)$ comprises a chip sequence c_j applied to a communication channel characterizable by an impulse response $h(t)$, and wherein the chip sequence c_j is generated from a data sequence d_i spread by the spreading sequence S_i and wherein T_c is the chip period of the chip sequence c_j;

means for generating an estimated communication channel impulse response $\hat{h}_M(t)$ as a combination of $co_m(t)$ and d_m for $m = 0,1,\Lambda\ ,M$; and

a filter means f, selected at least in part according to the spreading sequence S_i, the filter means for filtering the first estimated communication channel impulse response $\hat{h}_M(t)$ to generate the estimated communication channel impulse response $h(t)$ with

21. The apparatus of claim 20, wherein the filter means f is further selected at least in part according to an autocorrelation $A(n)$ of the spreading sequence S_i.

22. The apparatus of claim 21, wherein the filter means f is further selected at least in part according to the duration of the impulse response of the communication channel $h(t)$.

23. The apparatus of claim 21, wherein the filter means f is further selected at least in part according to a zero-forcing criteria $\sum_{i=-L}^{L}(A(n-i)\bullet f(i)) = A_f(n), -L \le n \le L$, wherein:

$f(i)$ is the impulse response of the filter means f such that $A_f(n)$ is a convolution of $A(n)$ and $f(i)$;

$A_f(n) = 1$ for $n = 0$ and $A_f(n) = 0$ for $0 < |n| \le L$; and

$A(n) = A(-n) = \sum_{i=o}^{N-1-n} S_i \bullet S_{i+n}, 0 \le n \le N$, and N is a length of the chip sequence S_i.

24. The apparatus of claim 23, wherein:

the parameter L is chosen such that a time duration of the impulse response of the communication channel $h(t)$ is less than LT_c.

25. The apparatus of claim 23, wherein:

the parameter L is chosen such that a time duration of the impulse response of the communication channel $h(t)$ is approximately equal to LT_c.

26. The apparatus of claim 20, wherein N is less than 20.

27. The apparatus of claim 20, wherein $M = 0$.

28. The apparatus of claim 20, wherein the data sequence d_i includes a constrained portion Cd_i associated with at least two codes w_0, w_1, wherein a correlation $A_{code}(k)$ of the constrained portion Cd_i with one of the codes w_0, w_1 is characterized by a maximum value at $k = 0$ less than maximum values at $k \ne 0$.

29. The apparatus of claim 28, wherein the means for generating an estimated communication channel impulse response $\hat{h}_M(t)$ as a combination of $co_m(t)$ and d_m for $m = 0,1,\Lambda\ ,M$ comprises means for computing $\hat{h}_M(t)$ as $\frac{1}{M}\sum_{m=0}^{M-1} d_m \bullet co(t + mNT_c)$.

30. The apparatus of claim 29, wherein $M=2$.

31. The apparatus of claim 28, wherein the data sequence d_i includes a preamble having a pseudorandom code including the constrained portion of the data sequence d_i.

32. The apparatus of claim 28, wherein $A_{code}(k) = 1$ at $k = 0$ and $A_{code}(k) = 0$ for substantially all $k \neq 0$.

33. The apparatus of claim 28, wherein $A_{code}(k) = 0$ for $0 < |k| \leq J$, wherein J is selected to minimize the correlation of the constrained portion Cd_i with the one of the codes w_0, w_1 for substantially all $k \neq 0$.

34. The apparatus of claim 33, wherein $2J$ is a length of the constrained portion Cd_i.

35. The apparatus of claim 20, wherein $A_{code}(k) = 1$ at $k = 0$ and $A_{code}(k) = 0$ for substantially all $k \neq 0$.

36. The apparatus of claim 20, wherein each of the two codes w_0, w_1 comprises two symbols.

37. The apparatus of claim 20, wherein the each of the two codes w_0, w_1 comprises no more than two symbols.

38. The apparatus of claim 20, wherein the codes w_0, w_1 comprise Walsh codes.

39. An apparatus for estimating a communication channel impulse response $h(t)$, comprising:

a correlator generating $co_m(t) = co(t + mNT_c)$ for $m = 0,1,\Lambda ,M$ by correlating a received signal $r(t)$ with a spreading sequence S_i of length *N*, wherein the received signal $r(t)$ comprises a chip sequence c_j applied to a communication channel characterizable by an impulse response $h(t)$, and wherein the chip sequence c_j is generated from a data sequence d_i spread by the spreading sequence S_i and wherein T_c is the chip period of the chip sequence c_j;

an estimator for generating an estimated communication channel impulse response $\hat{h}_M(t)$ as a combination of $co_m(t)$ and d_m for $m = 0,1,\Lambda ,M$; and

a filter *f* selected at least in part according to the spreading sequence S_i , the filter for filtering the first estimated communication channel impulse response $\hat{h}_M(t)$ to generate the estimated communication channel impulse response $h(t)$.

40. The apparatus of claim 39, wherein the filter *f* is further selected at least in part according to an autocorrelation $A(n)$ of the spreading sequence S_i.

41. The apparatus of claim 40, wherein the filter *f* is further selected at least in part according to the duration of the impulse response of the communication channel $h(t)$.

42. The apparatus of claim 40, wherein the filter f is further selected at least in part according to a zero-forcing criteria $\sum_{i=-L}^{L}(A(n-i) \bullet f(i)) = A_f(n), -L \leq n \leq L$, wherein:

$f(i)$ is the impulse response of the filter f such that $A_f(n)$ is a convolution of $A(n)$ and $f(i)$;

$A_f(n) = 1$ for $n = 0$ and $A_f(n) = 0$ for $0 < |n| \leq L$; and

$A(n) = A(-n) = \sum_{i=o}^{N-1-n} S_i \bullet S_{i+n}, 0 \leq n \leq N$, and N is a length of the chip sequence S_i.

43. The apparatus of claim 42, wherein:

the parameter L is chosen such that a time duration of the impulse response of the communication channel $h(t)$ is less than LT_c.

44. The apparatus of claim 42, wherein:

the parameter L is chosen such that a time duration of the impulse response of the communication channel $h(t)$ is approximately equal to LT_c.

45. The apparatus of claim 39, wherein N is less than 20.

46. The apparatus of claim 39, wherein $M = 0$.

47. The apparatus of claim 39, wherein the data sequence d_i includes a constrained portion Cd_i associated with at least two codes w_0, w_1, wherein a correlation $A_{code}(k)$ of the constrained portion Cd_i with one of the codes w_0, w_1 is characterized by a maximum value at $k = 0$ less than maximum values at $k \neq 0$.

48. The apparatus of claim 47, wherein the estimator for generating an estimated communication channel impulse response $\hat{h}_M(t)$ as a combination of $co_m(t)$ and d_m for $m = 0,1,\Lambda\ ,M$ comprises means for computing $\hat{h}_M(t)$ as $\frac{1}{M}\sum_{m=0}^{M-1} d_m \bullet co(t + mNT_c)$.

49. The apparatus of claim 48, wherein $M=2$.

50. The apparatus of claim 47, wherein the data sequence d_i includes a preamble having a pseudorandom code including the constrained portion of the data sequence d_i.

51. The apparatus of claim 47, wherein $A_{code}(k) = 1$ at $k = 0$ and $A_{code}(k) = 0$ for substantially all $k \neq 0$.

52. The apparatus of claim 47, wherein $A_{code}(k) = 0$ for $0 < |k| \leq J$, wherein J is selected to minimize the correlation of the constrained portion Cd_i with the one of the codes w_0, w_1 for substantially all $k \neq 0$.

53. The apparatus of claim 52, wherein $2J$ is a length of the constrained portion Cd_i.

54. The apparatus of claim 39, wherein $A_{code}(k) = 1$ at $k = 0$ and $A_{code}(k) = 0$ for substantially all $k \neq 0$.

55. The apparatus of claim 39, wherein each of the two codes w_0, w_1 comprises two symbols.

56. The apparatus of claim 39, wherein the each of the two codes w_0, w_1 comprises no more than two symbols.

57. The apparatus of claim 39, wherein the codes w_0, w_1 comprise Walsh codes.